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(54) Abstract Title
Vehicle roll control

(57) An active vehicle roll control system in which a roll bar 22 has two halves 22a, 22b which can be locked together to allow the system to operate passively. A sensing system, such as a gear lever position sensor is arranged to detect when the vehicle is travelling in reverse and to put the roll control system into the passive mode.

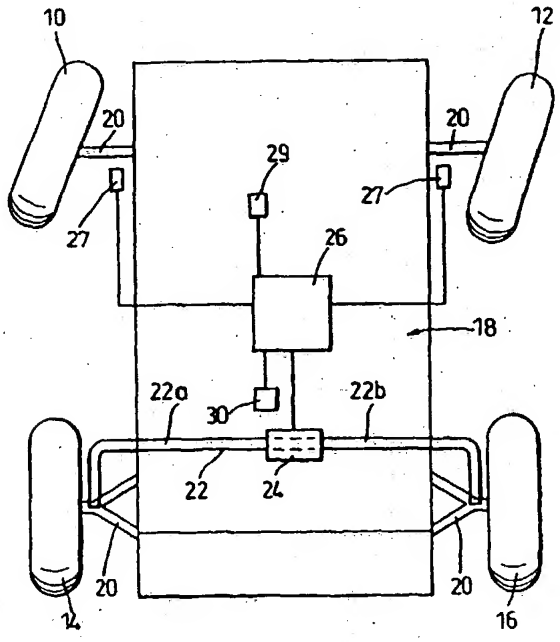

Fig. 1

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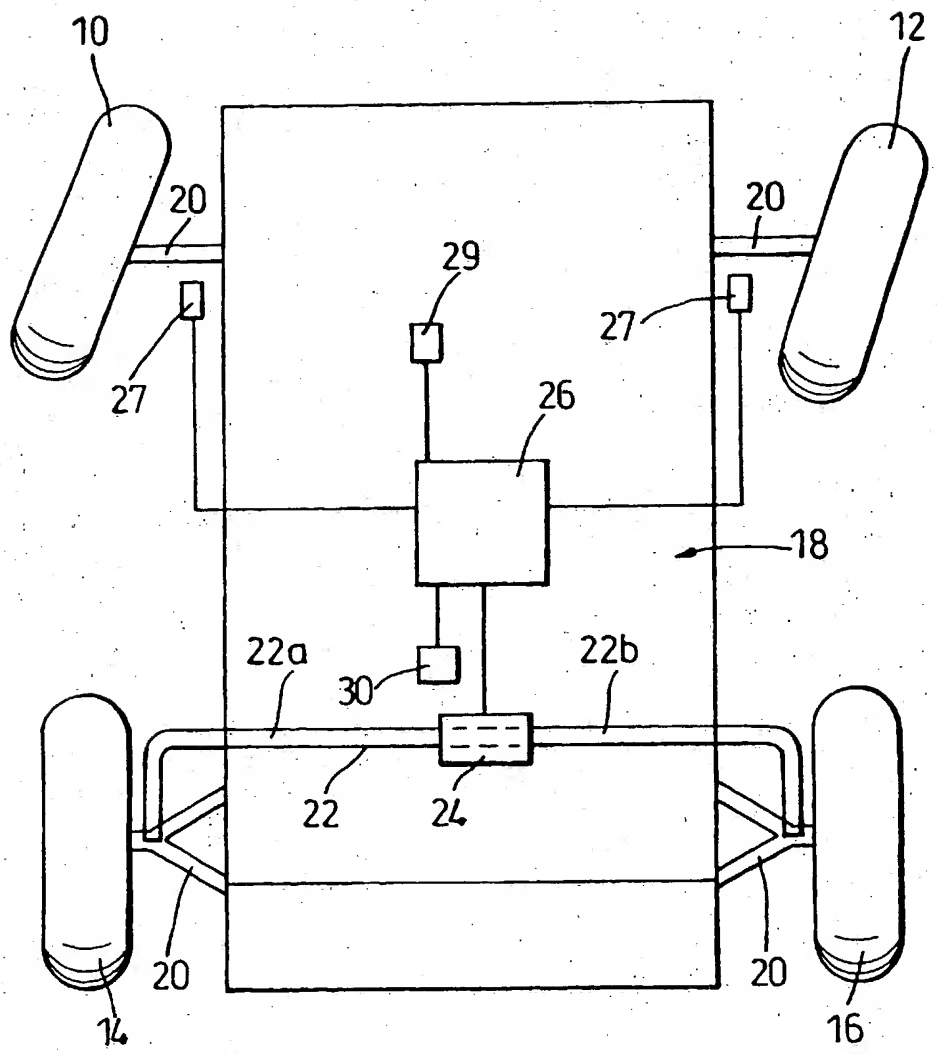

Fig 1

Vehicle Roll Control

The present invention relates to active suspension systems for vehicles, and in particular to such systems which include active roll control.

The present invention provides an active roll control system for a vehicle comprising lateral acceleration measuring means arranged to measure lateral acceleration of the vehicle, actuation means arranged to provide a force on a sprung part of the vehicle to reduce vehicle roll, and control means arranged to control the actuation means to control said force in response to signals from the lateral acceleration measuring means, wherein the lateral acceleration measuring means is arranged to measure the direction of lateral acceleration of the vehicle in a manner which is dependent on the direction of yaw of the vehicle, the system further comprising reverse travel detection means and the control means being arranged to modify its roll control strategy in response to the detection of reverse travel of the vehicle.

Preferably the control means is arranged in a normal mode to control the actuation means so as actively to increase said force with increasing lateral acceleration of the vehicle over at least a range of lateral accelerations and, on detection of reverse travel of the vehicle, to operate in a reverse mode in which the actuation means operates passively over said

Preferably the lateral acceleration measuring means comprises two accelerometers spaced apart from each other in the direction of normal travel of the vehicle.

Preferred embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic representation of a vehicle including a suspension according to an embodiment of the invention,

Referring to Figure 1, a vehicle has four wheels 10, 12, 14, 16 each mounted on the vehicle body 18. The vehicle has an independent suspension, each of the wheels being attached to the body 18 through a suspension arm 20 so that it can move vertically relative to the body 18. A roll bar 22 is connected between the two rear wheels 14, 16 to control the roll of the rear of the vehicle. The roll bar 22 is split in the middle into two halves 22a, 22b which can be rotated relative to each other by a rotary actuator 24 under the control of a control unit 26. This enables vehicle roll to be controlled actively in response to signals input to the control unit from wheel speed sensors 27 first and second lateral accelerometers 29, 30 which provide signals indicative of the acceleration of parts of the vehicle body in various directions as will be described in more detail below. A similar roll

bar, which is not shown, would also normally be connected between the front wheels 10, 12. The control unit 26 can control the actuator 24 so as to operate in four states. These comprise a locked state in which the two halves 22a, 22b of the anti-roll bar 22 are locked together and the anti-roll bar therefore resists vehicle roll passively like a conventional one-piece torsion bar, an unlocked mode in which the two halves of the ant-roll bar are free to rotate relative to each other so it does not resist vehicle roll, a left assist mode in which it provides an actively controlled force tending to cause the vehicle to roll to the left and a right assist mode in which it provides actively controlled force tending to cause the vehicle to roll to the right. In the left assist and right assist modes, the actuator force increases with increasing lateral acceleration of the vehicle over a range of lateral accelerations between the minimum and maximum forces which can be produced by the actuator.

Considering the lateral accelerometers 29, 30 in more detail, the first lateral accelerometer 29 is positioned close to the front end of the vehicle, and the second lateral accelerometer 30 is positioned close to the rear axle of the vehicle. When the vehicle is travelling forwards with the front steered wheels turned to the right as shown, both of these accelerometers will measure an acceleration to the right. Under these conditions the body will tend to roll to the left, and the control unit is arranged to apply a torque to

wheels turned to the right, both the accelerometers 29, 30 will still measure an acceleration towards the right, though that measured by the front accelerometer 29 will be greater than that of the rear accelerometer. This is because the front end of the vehicle will be turning in a wider arc than the rear, at the same angular velocity. However, the control unit can still determine from the measured lateral accelerations that the vehicle is turning to the right, and apply the correct controls to the actuator 24.

If the vehicle starts to reverse from rest, with the front wheels still turned towards the right as shown, the front end of the vehicle will swing out to the left, and the front accelerometer 29 will measure an acceleration towards the left. Depending on the exact position of the rear accelerometer it may also measure a slight acceleration to the left or to the right. Generally the vehicle will rotate in yaw about a point mid way between the two rear wheels 14, 16. Therefore if, as is shown here, the rear accelerometer is forward of the rear axle, its will measure a small acceleration to the left. If it were to the rear of the rear axle it would measure a small acceleration to the right. In any event it will be appreciated that the measured accelerations will be very different, and will generally be in the opposite direction, when the vehicle is travelling in reverse from if it is travelling forwards, particularly at low speeds and high steering angles. Therefore, if the control unit 26 were to perform its anti-roll

function in the same way during reverse travel as during forward travel, it would magnify the vehicle roll rather than reduce it.

In order to compensate for this problem, the vehicle is provided with a sensor 32 for detecting when the vehicle is travelling in reverse and, when reverse travel is detected, the control unit 26 is arranged to put the roll control actuator into its locked mode. The sensor 32 comprises a gear lever position switch which simply detects when reverse gear has been selected. However it could equally comprise a sensor for sensing the direction of travel of one or more of the vehicle wheels 10, 12, 14, 16, or of a part of the vehicle power train.

The control unit is also arranged to monitor the roughness of the surface over which the vehicle is travelling by monitoring the variations in wheel speeds of the four wheels 10, 12, 14, 16. Under normal operation the control unit 26 is arranged to put the actuator 24 into its unlocked mode on detection of a rough driving surface, so as to provide a smooth ride. This function operates in the same way when the vehicle is travelling in reverse as when it is travelling forwards.

It will be appreciated that the present invention will be applicable in any roll control system in which the measurement of lateral acceleration, and in particular its direction, is dependent on the direction of yaw of the

vehicle. For example in a system having only a single lateral accelerometer which is near the front end of the vehicle, the measured lateral acceleration will, at least at low speeds and high steering angles, reverse in direction if the direction of travel of the vehicle is reversed.

It will also be understood that the present invention is suitable for roll control systems using any of a variety of known actuators to control vehicle roll. For example independent air suspension systems which include a roll control strategy in the control of air pressure in the gas struts at each of the wheels could use the present invention, as could systems using an anti-roll bar with other forms of actuator, such as those having a hydraulically operated strut to control rotation of one end of the anti-roll bar about the central torsion part of the bar, as shown, for example, in WO98/26948.

CLAIMS

1. An active roll control system for a vehicle comprising lateral acceleration measuring means arranged to measure lateral acceleration of the vehicle, actuation means arranged to provide a force on a sprung part of the vehicle to reduce vehicle roll, and control means arranged to control the actuation means to control said force in response to signals from the lateral acceleration measuring means, wherein the lateral acceleration measuring means is arranged to measure the direction of lateral acceleration of the vehicle in a manner which is dependent on the direction of yaw of the vehicle, the system further comprising reverse travel detection means and the control means being arranged to modify its roll control strategy in response to the detection of reverse travel of the vehicle.

2. A system according to claim 1 wherein the control means is arranged in a normal mode to control the actuation means so as actively to increase said force with increasing lateral acceleration of the vehicle over at least a range of lateral accelerations and, on detection of reverse travel of the vehicle, to operate in a reverse mode in which the actuation means operates passively over said range of lateral accelerations.

3. A system according to claim 1 or claim 2 wherein the lateral acceleration measuring means comprises two accelerometers spaced apart from each other in the direction of normal travel of the vehicle.

4. A system according to any foregoing claim wherein the actuation means is normally operable in four modes comprising a locked mode in which it resists vehicle roll passively, an unlocked mode in which it does not resist vehicle roll, a left assist mode in which it provides an actively controlled force causing vehicle roll to the left and a right assist mode in which it provides actively controlled force causing vehicle roll to the right, and wherein the left assist and right assist modes are effectively disabled in response to the detection of reverse travel.

5. A system according to claim 4 wherein, when reverse travel has been detected, the system is arranged to measure the roughness of the surface over which the vehicle is travelling and to enter the unlocked mode in response to the detection of a rough surface.

6. A system according to any foregoing claim wherein the actuation means is arranged to control the force transmitted between an anti-roll bar and the vehicle body.

7. A vehicle suspension substantially as hereinbefore described with reference to the accompanying drawing.

The Patent Office

Application No:	GB 9821063.6	**Examiner:**	Colin Thompson
Claims searched:	1 to 7	**Date of search:**	26 January 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): B7D (DCB,DCH,DCT)

Int Cl (Ed.6): B60G17/015,21/10

Other: Online: WPI, EDOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
	None	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier